JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES
VOL. VI APRIL 19, 1916 No. 8

PHYSICS.—*A misconception of the criterion for gray body radiation.* PAUL D. FOOTE and C. O. FAIRCHILD, Bureau of Standards.

Some 15 years ago Lummer and Pringsheim[1] investigated spectrophotometrically the radiation of carbon and platinum by comparison with a black body at various known temperatures. It was found, when the carbon was maintained at a constant temperature and the temperature of the black body was altered, that the graph of the logarithm of the ratio of the intensities of the two sources at any given wave length plotted against the reciprocal of the absolute temperature of the black body was a straight line, and further that these linear graphs for various wave lengths in the visible spectrum intersected at one common point. The fact that such a common point of intersection existed was casually suggested as a possible proof of the "grayness" of carbon where the term gray is understood to denote that the material has an emissivity independent of the wave length. Consequently the value of the temperature coordinate corresponding to this point of intersection would be the true temperature of the gray radiating material.

Recently an extensive paper on this subject has been published by Elisabeth Benedict[2] working under the direction of Lummer and Pringsheim in which the following questions among others proposed by Dr. Lummer are considered.

[1] LUMMER and PRINGSHEIM. Verh. d. Deut. Phys. Ges. **3**: 36–42. 1901.
[2] BENEDICT. Ann. d. Phys. **47**: 641–678. 1915.

1. Are there materials which show true intersections of the logarithmic isochromatics?

2. Do these intersections furnish an exact measure of the true temperature?

Carbon was found to show the intersections referred to. The conclusion was accordingly made that carbon is gray and that the temperature corresponding to the point of the intersection is the true temperature of the carbon.

It is the purpose of this note to point out that these conclusions can not be drawn from the experimental data. It will be shown that even though the logarithmic isochromatics of various wave lengths do intersect in one common point, this point of intersection is *no immediate indication whatever of the true temperature of the non-black radiator, and is no proof that the radiator is even approximately gray.*

The radiation of a black body is compared spectrophotometrically with that of a non-black body.

J_1 = intensity of radiation of wave length λ from black body.

J_2 = intensity of radiation of wave length λ from non-black body.

θ = absolute temperature of black body.

T = absolute true temperature of non-black body.

A = emissivity coefficient of non-black body which in general is a function of both T and λ.

The question of A as a function of T is not considered in the present note. We shall accordingly assume A to be a function of λ only.

$$(1) \quad J_1 = c_1 \lambda^{-5} e^{-\frac{c_2}{\lambda\theta}}$$

(Wien's law for black body.)

$$(2) \quad J_2 = c_1 \lambda^{-5} A e^{-\frac{c_2}{\lambda T}}$$

(Analogous law for non-black body.)

Whence

$$(3) \quad \log_e \frac{J_2}{J_1} = \log_e A + \frac{c_2}{\lambda}\left(\frac{1}{T} - \frac{1}{\theta}\right)$$

Suppose that A can be represented, within observational errors, by a function of the following form, where p and A' are constants

$$(4) \quad \begin{cases} A = A' e^{\frac{c_2 p}{\lambda}} \\ \log_e A = \log_e A' + \frac{c_2 p}{\lambda} \end{cases}$$

Substituting in (3)

$$(5) \quad \log_e \frac{J_2}{J_1} - \log_e A' = \frac{c_2}{\lambda}\left(\frac{1}{T} + p - \frac{1}{\theta}\right)$$

Since by the method in question T is maintained constant, the only variables being J_2/J_1, λ and θ, the above equation is of the form

$$(6) \quad (y - a) = m\,(b - x)$$

i.e. a family of straight lines with the variable parameter c_2/λ. The common point of intersection has the coordinates $\log_e A'$ and $\frac{1}{T} + p$.

We have accordingly shown that the intersection may occur when the material is not gray and that the temperature corresponding to the point of intersection T' is not the true temperature T but related to it by the reciprocal expression $\frac{1}{T'} = \frac{1}{T} + p$, where p is a constant which requires an entirely different mode of experimentation for its determination. It is of course recognized that only a few functions of the type represented by equation (4) will satisfy the condition that intersections of the isochromatics occur, and that there is probably no physical reason why the true emissivity relation should take this one peculiar form, which invalidates the conclusion that the emissivity must be independent of the wave length. But it may be remarked that the intersections are never perfect, that the straight lines at best are only a smoothed mean of the observed points, that there are only a few radiating materials which do show intersections, and finally that within the observational errors involved in work upon radiation the proper choice of A' and p of equation (4) will satisfactorily determine almost any function desired.

As a particular illustration of the possible erroneous conclusions which may be drawn from the intersection of isochromatics, viz. that the radiating material is gray and that the temperature corresponding to the intersection is the true temperature of the radiator, the following example may be cited, in which the radiation from a black body at various temperatures is compared with that from a non-black and non-gray body. There can be no question that this particular radiator is not gray. We have purposely made it as far from gray as conveniently possible.

Temperature of non-black radiator = 1400° *abs.*

WAVE LENGTH	EMISSIVITY
0.4μ	0.102
0.5	0.280
0.6	0.549
0.7	0.889

The logarithmic isochromatics obtained by (theoretically) comparing this radiator with a black body at temperatures 1200°, 1300°, 1500°, and 1600° absolute are shown in figure 1. A per-

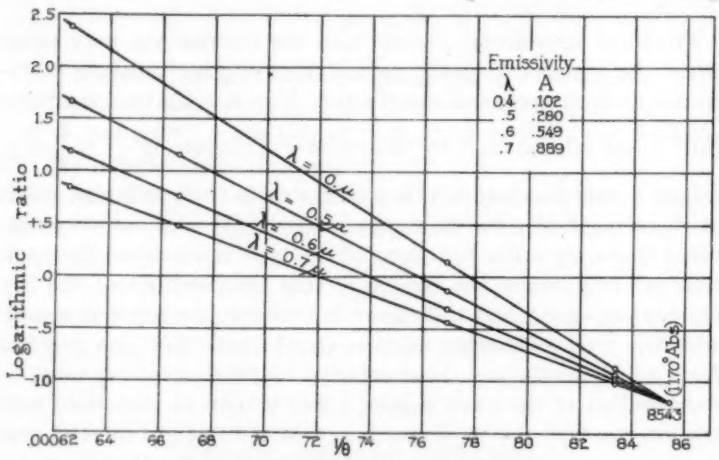

Fig. 1

fect intersection occurs at the temperature 1170° absolute. Following the criterion of Lummer and Pringsheim as applied by Benedict we would conclude that this radiator is gray and is at

the temperature 1170° absolute. Actually this radiator is very far from gray and has the temperature 1400° absolute.

Using the valuable method of isochromatics and considering the constant p of equation (4) the writers hope to present later experimental data on the emissivity of carbon. It may be remarked that the intersections used directly give simply the temperature at which a color match is obtained. It is also interesting to note that a non-black material may show the energy distribution of a gray body and still not be gray. That is, it is theoretically possible to obtain a color match against a black body with *certain* materials which have an emissivity coefficient varying greatly with the wave length. It is theoretically possible to have two radiators at different temperatures, one gray and the other far from gray, giving an exact color match, and an exact intensity match at every wave length.

BOTANY.—*Rolliniopsis, a new genus of Annonaceae from Brazil.* W. E. SAFFORD, Bureau of Plant Industry.[1]

Among the plants collected by Messrs. Dorsett, Shamel, and Popenoe while on their mission of agricultural exploration in Brazil, in 1914, there is one of peculiar interest, belonging to the Annonaceae, with 3-winged flowers resembling those of a Rollinia but with clusters of small, one-seeded, orange-colored fruits very much like those of a Guatteria or Aberemoa. A photograph of the flower and fruit was taken in the field, and plants propagated from the seeds were distributed by the Office of Foreign Seed and Plant Introduction, Bureau of Plant Industry, bearing the label "Guatteria sp., S. P. I. No. 37902."

A second species having the same botanical features was brought back from Brazil more recently by Dr. J. N. Rose and Mr. P. G. Russell, who collected it in the state of Bahia, in the summer of 1915, while carrying on botanical exploration under the auspices of the Carnegie Institution of Washington.

For these and two allied plants hitherto assigned to the genus Rollinia (*R. parviflora* St. Hil. and *R. leptopetala* R. E. Fries) must be created a new genus, for which I here propose the name Rolliniopsis.

[1] Published with the permission of the Secretary of Agriculture.

Rolliniopsis Safford, gen. nov.

Flowers resembling those of Rollinia, solitary or in clusters of 2 or 3. Calyx gamosepalous, 3-lobed. Corolla gamopetalous, the lobes corresponding to the outer petals of other Annonaceae produced into three spreading obtuse spurs or compressed rounded wings, the three alternate inner lobes connivent in such a way as to leave only a very small opening above the gynœcium. Stamens minute, numerous, closely crowded on the torus, the connective produced into a thin transverse shield above the pollen sacs, these linear, parallel, and contiguous, opening extrorsely by a longitudinal fissure. Carpels several to many, forming a cluster (gynœcium) in the center of the mass of stamens just below the opening of the corolla; ovaries 1-ovuled. Receptacle (torus) at length indurated and bearing a cluster of distinct fruits, these closely crowded but not concrescent nor compressed into prisms or angular pyramids. Fruits small, pyriform or ovoid, containing a single seed surrounded by a thin layer of aromatic pulp (mesocarp), very much as in the genus Guatteria. Seeds pyriform, obovoid, or ovoid, the thin testa somewhat wrinkled by the inclosed ruminate endosperm and marked by a longitudinal line from the small basal hilum to the rounded apex.

TYPE SPECIES: *Rolliniopsis discreta* Safford.

GEOGRAPHICAL RANGE: Brazil, from the State of Bahia to Minas Geraës.

This genus is separated sharply from Guatteria by its 3-winged flowers. From Rollinia[2] it differs chiefly in its fruits, which consist of a cluster of separate, or discrete, carpels instead of a fleshy Annona-like syncarpium. Its relation to Rollinia is very much the same as that of Aberemoa or Duguetia to the genus Annona. The seeds differ from those of a typical Rollinia in their minute hilum; and the fruits, instead of having a sugary, juicy pulp like that of the commercial custard-apples, possess a thin aromatic mesocarp surrounding the seed, very much like that of certain species of Xylopia known in Brazil as "monkey peppers" and in Panama as "*malaguetas*," suggesting also the flavor of the Mexican *xochinacaztli*, or "ear-flower" (*Cymbopetalum penduliflorum*), whose petals were used by the Aztecs as an ingredient of their chocolate.

KEY TO THE SPECIES

Leaf blades oblong-elliptical or oblong-lanceolate.
Nerves 7 to 9 on each side.....1. *R. discreta.*
Nerves 9 to 13 on each side.....2. *R. simiarum.*

[2] Prantl, in an analytical key of the section Xylopieae, briefly distinguishes the genus Rollinia as follows: "Kronenb. über dem holen Grunde seitlich zusammengedrückt; Fr. verschmolzen." Nat. Pflanzenfam. 3[2]: 35. 1891.

Leaf blades broadly elliptical
Flowers minute; young branches ferruginous-tomentose; leaf blades acute.....3. *R. parviflora.*
Flowers medium-sized (winged petals about 1 cm. long); young branches fulvous-tomentose; leaf blades round-tipped.....4. *R. leptopetala.*

1. **Rolliniopsis discreta** Safford, sp. nov.

A small tree, 6 to 9 meters high. Vegetative branches not observed; flowering branches slender, grayish brown, thickly dotted with gray lenticels and bearing prominent leaf scars. Leaf blades oblong-elliptical, rounded or obtuse at the base, usually rounded or obtuse or sometimes slightly retuse at the apex, variable in size, when normal 7 to 8 cm. long, 2.5 to 3 cm. broad, with 7 to 9 nerves on each side; smaller blades near extremities of branchlets 5 cm. long, 1.5 cm. broad; petioles 5 to 7 mm. long, often recurved, broadly grooved above, clothed with fine grayish tomentum; blades membranaceous but firm, minutely tomentose with short whitish hairs on both surfaces, more densely so beneath; midrib impressed above, prominent beneath and tomentose like the petiole. Flowers (fig. 1) solitary or in 2's or 3's; peduncles extra-axillary or opposite a leaf, straight or curved and wirelike, 10 to 17 mm. long, clothed with minute reddish brown tomentum, subtended at the base by a small sessile tomentose bracteole and usually bearing a second minute clasping bracteole at or below the middle; calyx 3-lobed, clothed outside with reddish tomentum like that of the peduncle, the divisions broadly triangular, 5 mm. broad, 3 mm. high; corolla reddish brown, the 3 lobes corresponding to outer petals compressed laterally into thin orbicular vertical wings 11 to 12 mm. in diameter, minutely tomentellous (as seen under the microscope), the 3 lobes corresponding to inner petals minute, grayish-puberulent, connivent. Stamens numerous, minute (0.6 mm. long, 0.2 mm. broad), with the reddish brown connective expanded above the two straw-colored parallel pollen sacs. Gynœcium composed of about 50 carpels, these remaining distinct and developing into a cluster of small drupes. Mature fruit cluster 4 cm. in diameter; indurated receptacle 8 to 12 mm. in diameter; drupes pyriform, sessile, often somewhat oblique, 12 to 14 mm. long, 7 to 8 mm. in diameter, rounded at the apex and terminating in a short oblique point, gradually narrowing toward the base; pericarp bright orange, turning dark brown in drying; seeds pyriform or obovoid, enveloped in a thin layer of aromatic pulp, 9 to 10 mm. long, 4 to 5 mm. in diameter, the testa light brown, slightly wrinkled by

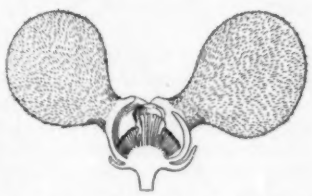

Fig. 1. Flower of *Rolliniopsis discreta*, with portion removed to show crowded stamens surrounding the central gynœcium. Scale about 1.5.

Fig. 2. *Rolliniopsis discreta* Safford.

the corrugations of the enclosed ruminate endosperm, marked on one side by a longitudinal line extending from the small basal hilum to the rounded apex.

Type in the U. S. National Herbarium, No. 865593, collected and photographed at Januaria, State of Minas Geraës, Brazil, February 15, 1914, by Messrs. Dorsett, Shamel, and Popenoe (No. 371 b; photograph, Field No. 1855, File No. 15508; seeds, No. 125a). "A small tree 20 to 25 feet high, common between Januaria and Brejo, 4 miles back from the river. Fruits bright orange; called *'fruta de macaco'* [monkey-fruit]."

EXPLANATION OF FIG. 2.

The type specimen of *Rolliniopsis discreta*, showing flowering branches with leaves, flower, and fruits both immature and mature; *a*, stamen, dorsal view; *b*, stamen, ventral view; *c*, two mature carpels which have fallen from the receptacle; *d*, seed. Branches with flower and fruits, and detached carpels and seed, *c*, *d*, natural size; *a*, *b*, scale 10.

2. **Rolliniopsis simiarum** Safford, sp. nov.

A small irregularly branching tree with small narrow round-pointed leaf blades, 3-winged flowers, and dense clusters of small yellow aromatic berries. Young growth grayish-tomentulose, the branchlets soon becoming glabrous, those of the vegetative growth slender, zigzag, with reddish brown bark sparsely dotted with lenticels, those terminating the limbs often irregular, with grayish bark, short internodes, and prominent leaf scars. Leaf blades variable in shape, those at the base of the branchlets smaller and relatively broader than the succeeding ones; normal leaf blades oblong-lanceolate, rounded or very slightly retuse at the apex, rounded at the base, 8 to 10 cm. long, 2.8 to 3.5 cm. broad, with 9 to 13 nerves on each side, membranaceous, deep green above, paler beneath, yellowish green or olivaceous when dry, apparently glabrous on both faces but as seen under the microscope clothed with scattered minute curved whitish hairs; midrib impressed above, prominent beneath, reddish brown, sparsely clothed with grayish hairs; parenchyma between the lateral nerves divided into polygonal areoles by fine reticulating veins; petioles broadly grooved above, clothed at first with grayish tomentellum, those of the normal leaves 6 to 8 mm. long, of the smaller leaves 3 to 5 mm. long. Flowers (only the detached petals of one flower observed) reddish brown when dry; petals laterally compressed, winglike, suborbicular, abruptly contracted at the base, 11 mm. long, 9 mm. broad; calyx persistent (observed only on dry fruits), 3-lobed, the divisions rounded or obtuse at the apex, 2 mm. broad, 1.8 mm. high; peduncles (only those of fruit observed) at length woody, 12 to 21 mm. long. Fruit a cluster of small distinct sessile carpels borne on the indurated receptacle; mature carpels aromatic, pyriform or obovoid, 8 to 12 mm. long, 5 to 6 mm. in diameter, rounded or abruptly beaked at the apex, gradually narrowed at the base; pericarp glabrous, yellow when fresh, dark brown or blackish when dry; seed solitary, obovoid or pyriform,

sometimes slightly compressed, 7 to 10 mm. long, 4 to 5 mm. in diameter, the testa light brown, slightly wrinkled by the corrugations of the inclosed ruminate endosperm, the hilum basal, small, and inconspicuous.

Type in the U. S. National Herbarium, No. 762291, collected in the vicinity of Machado Portella, State of Bahia, Brazil, June 19–23, 1915, by J. N. Rose and P. G. Russell (No. 19963).

The specific name chosen for this plant was suggested by its Portuguese vernacular name, *fruta de macaco* [monkey fruit].

3. **Rolliniopsis parviflora** (St. Hil.) Safford.

Rollinia parviflora St. Hil. Fl. Bras. Merid. **1**: 30. 1825.

A small tree with rufous-pubescent branchlets. Leaf blades 4 to 6.4 cm. long, 1.8 to 2.5 cm. broad, oblong, acuminate at the apex, acute at the base, glabrous above, puberulous beneath, the midrib prominent, ferruginous-pubescent, the lateral nerves parallel; petioles about 4 mm. long, nearly terete, ferruginous-pubescent. Flowers small, the peduncles solitary, 4 to 6 mm. long, recurved, slightly thickened at the apex, ferruginous-villous. Calyx ferruginous-villous, 3-lobed, the divisions broadly ovate, acute. Corolla 3 to 5 mm. long and broad, villous, green to rufescent, 6-lobed; lobes thick and obtuse, horizontally spreading, those corresponding to the inner petals of other Annonaceae a little narrower than the others, nearly orbicular. Torus convex on top, bearing a cluster of about 15 carpels at its apex and below these a mass of minute, closely crowded stamens (about 1 mm. long). Fruit a cluster of small oblong-ovoid sessile drupes, these 1 cm. long, 5 mm. in diameter, closely crowded on the indurated receptacle, but quite distinct and falling off separately when mature, like those of Guatteria.

Type collected by Augustin St. Hilaire "in sylvis primaevis montis *Tejuca* propè Sebastianopolim [Rio de Janeiro]. Florebat Novembre."

Rolliniopsis parviflora can readily be distinguished from the two preceding species as well as from *R. leptopetala* by the minute size of its flowers and the relatively short and thick lobes of the corolla.

In the type material collected and described by St. Hilaire there were no specimens of fruit and the fruit remained unknown until 1905, when R. E. Fries described it from specimens collected by Riedel in the vicinity of Rio de Janeiro.[3] In the amended description of this

[3] "Die Früchte, die für diese Art bisher nicht bekannt sind, bieten ein sehr eigenthümliches Aussehen dar. Die Einzelfrüchte sind nicht in einem Syncarpium vereint; sie sind länglich eiförmig . . . und sitzen ungestielt auf dem Receptaculum dicht zusammen, unter einander jedoch frei; sie fallen auch von einander getrennt ab, wie z. B. bei den Guatterien. Hierin weicht *R. parviflora* von den allermeisten übrigen *Rollinia*-Arten ab, von denen man Früchte kennt; nur *R. leptopetala* R. E. Fr. hat die Frucht auf ähnliche Weise gebaut."—R. E. Fries, in Arkiv för Botanik, **5**[4]: 20. 1905.

species by Martius[4] the leaves are described as "ovate, ovate-lanceolate, or lanceolate," and two varieties are indicated: var. *α latifolia* and var. *β angustifolia*. Whatever varieties may be established, that which corresponds with the original description of the species must be regarded as the type form ("Rollinia foliis oblongis, acuminatis, basi acutis"). A specimen in the U. S. National Herbarium (No. 703471), collected by Riedel "in sylvis montosis propè Rio Janeiro, 1829," with most of the leaf blades broadly elliptical or oval and acuminate, belongs undoubtedly to the variety *latifolia*. The blades of the smaller leaves at the base of the flowering branchlets of this specimen are orbicular. It is quite possible that the leaves of vegetative branches would be relatively narrower, like those of the type described by St. Hilaire.

DISTRIBUTION: Known only from Brazil. Primeval forests of Mount Tejuca, vicinity of Rio de Janeiro, *St. Hilaire* (type, as cited above); *Glaziou* 6077; Mount Gabia and neighboring hills, *Martius*, *Sellow*, and *Lhotzky;* Serra Tinguá, *Schott;* Rio de Janeiro, without definite locality, *Sellow*, *Riedel;* "Versant de Copacabana," January 26, 1870, *Glaziou* 3859; without definite locality, *Glaziou* 2120.

4. **Rolliniopsis leptopetala** (R. E. Fries) Safford.

Rollinia leptopetala R. E. Fries, Kongl. Sv. Vet. Handl. **34**[5]: 50. *pl. 7, f. 3, 4.* 1900.

A tree or shrub, with gray to blackish gray bark, that of the young branches dotted with numerous light-colored lenticels; young branchlets, petioles, and peduncles tomentose with projecting yellowish hairs. Leaf blades broadly elliptical, rounded at the base and rounded or subemarginate at the apex, variable in size, reaching the dimensions of 8 cm. in length and 4.5 cm. in breadth, membranaceous, clothed on the upper surface more or less densely with short white hairs, at length glossy though still bearing scattered hairs; on the lower surface clothed with a uniform tomentellum of yellowish white hairs; midrib impressed above, beneath prominent, reddish brown like the principal lateral nerves (6 to 8 on each side); petioles 5 to 8 mm. long, narrowly grooved above. Peduncles 1 to 1.5 cm. long, bearing at the base and at the middle two small acute hairy bracteoles (1 mm. long). Flowers red, fragrant. Calyx lobes 2 mm. long, 2.5 mm. broad, rounded and abruptly acuminate at the apex, united at the base, clothed outside with reddish hairs, glabrous within. Outer petals obtuse, each bearing a thin ferruginous-pilose, rounded or cuneate wing 8 to 11 mm. long and, near the rounded apex, 6 to 8 mm. broad; inner petals (corolla lobes) 2.5 mm. long, 3 mm. broad, suborbicular, obtuse, clothed outside with minute grayish hairs, glabrous within. Stamens scarcely 1 mm. in length. Fruit (observed only on 1 specimen) spheroidal, 1.5 cm. in

[4] Fl. Bras. **13**[1]: 19. 1872.

diameter, composed of a few smooth ovoid carpels 8 mm. by 6 mm. in size, borne on the indurated receptacle. Seeds oval, 7 mm. long, 5 mm. in diameter, light yellow, smooth.

Type in the Berlin Botanical Museum, collected in the state of Piauhy, Brazil, in 1840, by George Gardner (No. 2033).

Fries compares the leaves of this species to those of *Rollinia longifolia*, which, however, are relatively narrower and are not rounded at the apex. He says that the flowers and fruit are more like those of *Rollinia emarginata*, but specimens of the latter in the U. S. National Herbarium show its fruit to be a solid syncarpium. To this species he assigns as a variety, *angustifolia*, a plant in the Berlin Botanical Museum collected at Rio de Janeiro by Glaziou, No. 13508, but of this he figures only a single leaf and gives no account of the flower or fruit. In his figure of the type[5] the wings of the corolla are shown as different from those of *Rolliniopsis discreta* in size and form, and the mature carpels as ovoid instead of pyriform as in the latter species; moreover he describes *R. leptopetala* as a tree or shrub with "ramulis, petiolis, pedunculisque fulvo-tomentosis" . . . . and its "jüngsten Sprosse von abstehenden gelblichen Haaren wollig." These characters readily serve to disinguish his species from both *R. discreta* and *R. simiarum*, as well as from the ferruginous-tomentose *R. parvifolia*.

PLANT PHYSIOLOGY.—*A field auxanometer.* G. N. COLLINS and J. H. KEMPTON, Bureau of Plant Industry.

In studying the effect of different environmental factors, such as light, temperature, and water supply, on the rate of growth of maize varieties, the lack of some means of measuring the elongation of plants growing naturally in the field has for several years been recognized as a serious obstacle. There are two principal requirements in securing satisfactory measurements: (1) In order to ascribe any observed difference in the behavior of two varieties to its environmental cause it is necessary to make the measurements at short intervals; (2) that due allowance may be made for individual diversity, it is essential to make simultaneous measurements of a number of plants. These conditions have been met by devising a form of auxanometer well adapted to

[5] Op. cit. *pl. 7, f. 3, 4.*

field conditions and sufficiently simple and inexpensive to permit the use of a number of instruments at one time. The following description is published in the belief that the instrument may be found useful in other fields.

The instrument is illustrated diagrammatically in figure 1. It consists of a light wooden box, *a*, 4 inches square and 12 inches in height constructed of ½ inch material. Passing entirely through the box is a glass rod or tube, *b*, about ⅛-inch in diameter and about 20 inches long. The lower end of this rod is attached to the growing plant by means of a copper wire and a light clip or wire hook. The rod is supported by a cord attached to a close fitting cork, *e*, through which the rod is passed. The cord leads over a pulley, *c*, to a counterpoise, *d*. The recording pen, *f*, is made of thin sheet copper bent into a shallow trough and attached to a light wooden arm supported on the cork. The driving mechanism consists of an ordinary alarm clock, *g*, placed face down. The milled head used in setting the hands is removed and replaced by a ⅛-inch brass rod, 7 inches long, drilled and slotted at the lower end in the same manner as the discarded milled head. A shallow groove also is cut in the upper end of the rod. The drum, *h*, for carrying the record paper is made of a section of a pasteboard mailing tube filled at either end with a perforated cork, through which the brass rod passes. A pin passed through the cork at the upper end rests in the shallow groove in the top of the brass rod. The counterpoise string for lifting the glass rod is attached near the edge of the cork, *e*, and the pressure of the pen on the drum can be regulated by a slight turning of this cork.

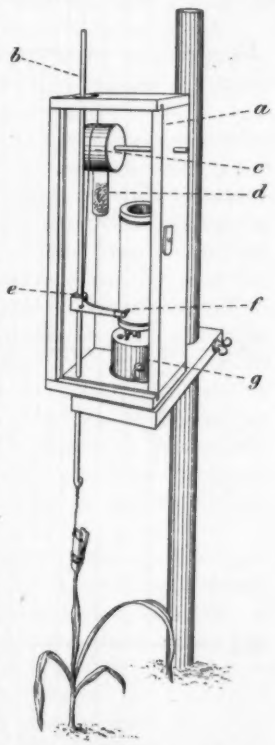

Fig. 1. Field auxanometer.

A convenient method of supporting the machine is to drive a round wooden stake by the side of the plant to be measured, on which a

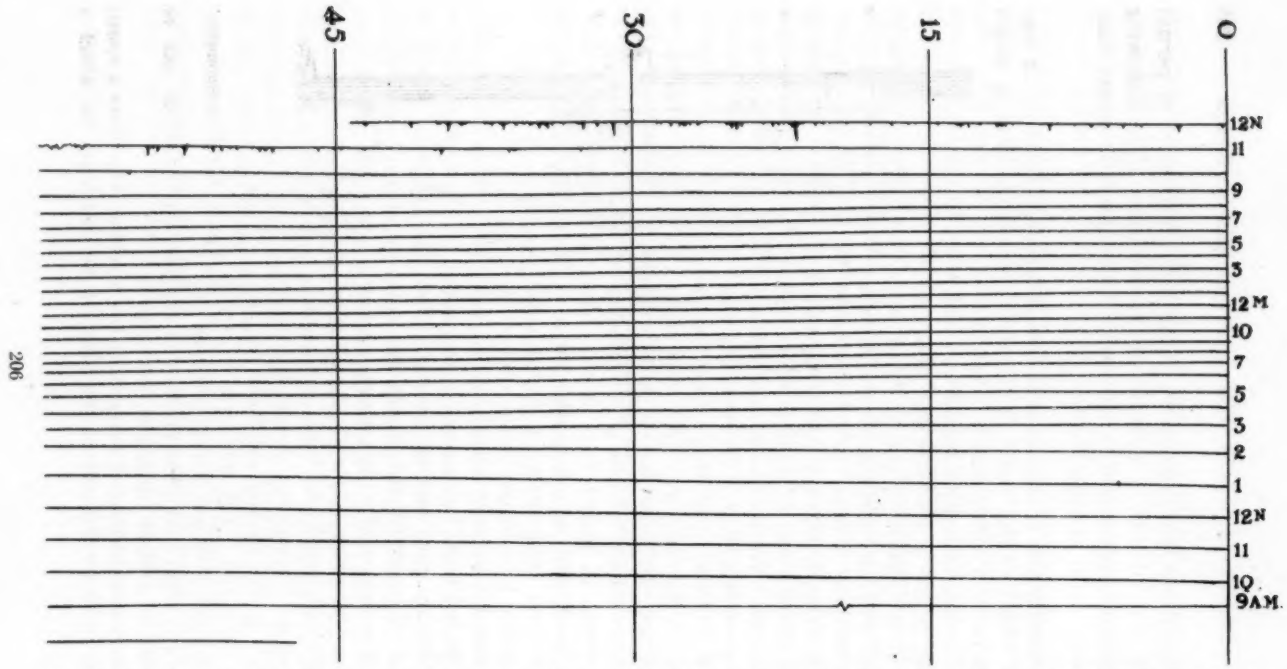

Fig. 2. Sample record of field auxanometer made on the seventh leaf of a Boone County white maize plant, Chula Vista, California, September 26, 1915. The irregularities during the last two hours show the effect of wind. Natural size.

wooden shelf is supported. A narrow slot is cut from one end of the shelf to within an inch or two of the other, and near the open end the slot is enlarged to pass over the stake. A bolt provided with a wing nut is passed edgewise through the board behind the opening for the stake, permitting the shelf to be fastened at the desired height. The auxanometer is attached to the shelf by means of a wood screw or bolt which passes through the slot and into the bottom of the box. This arrangement permits movement in either direction, and allows the instrument to be brought directly over the plant to be measured.

Satisfactory clocks can be had for $5.35 per dozen. The value of all other materials is trifling and the cost of the finished machines, including the labor, need not exceed $15.00 per dozen.

Since the recording pen is attached directly to the growing part of the plant by an inelastic rod, the accuracy of the measurements is not affected by lack of precision in the construction of the instrument. The only essential is that the parts move freely and with a minimum of friction. If the axis of the recording drum and the glass rod are not parallel, there will be a slight error in the absolute elongation recorded, but this error will be constant throughout the record and will not affect the comparative elongation of different periods. In this particular this simple auxanometer may claim advantages in accuracy over the more elaborate and expensive forms, in which the motion is transmitted by a flexible thread and the direction of the motion is changed by passing the thread over a revolving drum. With such instruments it is difficult to eliminate slight errors due to hygroscopic changes in the thread, and any inaccuracies in the curvature or centering of the drum are reflected in the measurements.

In the making of continuous measurements of plants in the open, the movement of the plant due to wind is always a disturbing element. With the instrument here described the displacement of the plant, of course, depresses the pen; but as the highest point that the pen can reach at any given time is the position of rest, the effect of wind is to cause a series of almost vertical lines always below the horizontal line that marks the true elongation. In very gusty weather, when the plants are unprotected, this may result in the formation of an almost continuous band, but even then the upper margin of this band records the correct elongation. The effect of a moderate wind is shown in the last two hours of the record reproduced in figure 2.

It is believed that the relatively high cost of the auxanometers that are on the market, together with the fact that they are not adapted

for use in the open, has seriously retarded the accumulation of information regarding individual and varietal diversity in the reaction of crop plants to changes in environment. In designing the present instrument, therefore, an effort was made to use only the cheapest material and the simplest form of construction, so that the cost might be kept down to a point that would permit the use of the instrument in sufficient numbers to acquire extensive data for statistical treatment.

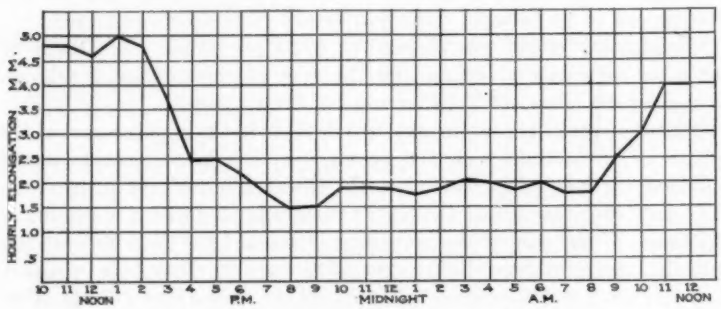

Fig. 3. Graph of hourly elongation, taken from record shown in figure 2.

Our observations on the rate of elongation in maize plants have led to the belief that in many of the investigations of periodicity in growth individual variation in the plants has not been adequately considered. For example, it was found that some plants showed a definite reduction in the rate of elongation between the hours of 8 and 10 a.m., while other plants of the same variety showed no such reduction. To detect differences of this kind it is necessary to secure records from a number of plants simultaneously, for if the records were taken on different days it would be difficult to exclude the possibility that differences in behavior were due to differences in the climatic conditions.

In many investigations it is equally important that measurements should be made on plants growing naturally in the field. With maize, at least, results obtained under greenhouse or laboratory conditions are quite at variance with results obtained in the open. In our experiments the only maize plants to exhibit a greater rate of elongation at night than in the day have

been greenhouse individuals. The question naturally arises, then, as to what extent the accepted belief that elongation is generally more rapid at night than in the day may be due to the fact that most experments on periodicity have been conducted under greenhouse or laboratory conditions.

ANTHROPOLOGY.—*Ritualistic origin myths of the Fox Indians.*[1] TRUMAN MICHELSON, Bureau of American Ethnology.

The Fox Indians of Iowa, who are probably the most primitive of all Algonkins within the borders of the United States, have an extremely extensive folk-lore and mythology. Their long systematic myths accounting for existing ceremonies are especially noteworthy, and it should be mentioned that the particular type of these myths is thus far unique.

To go into some details: The plots are all of one type. The hero is usually poor and sometimes ill-treated, but fasts and in a vision sees his supernatural helper or helpers. Ordinarily he has a vision of them four times and receives a little instruction each time. He then goes home, informs the people, and holds the ceremony in which he has been instructed. The ceremony is the one in actual use today. The songs are the existing ones, as are some of the set speeches. Usually the people subsequently are attacked by their enemies or there is a famine. In any case the hero always succors them.

Such topics as taboos, facial paintings, localizations in clan-feasts, descriptions of drums, positions in dancing, the number of ceremonial attendants and the gentes to which they belong, songs, set speeches, contents of sacred packs, and instruction regarding exogamy of gentes come up incidentally in these ritualistic origin myths. In so far as the actual ceremonies can rarely, if ever be witnessed in their entirety, owing to the conservative character of the Fox Indians, these myths are extremely valuable for strictly ethnological studies.

[1] Summary of an address delivered before the Anthropological Society of Washington, February 15, 1916. Published with the permission of the Secretary of the Smithsonian Institution.

It is the profusion of information contained in the Fox ritualistic origin myths that gives them their unique character in primitive literature. This applies especially to the incorporation of existing songs and set speeches.

Among the Piegans, as Wissler has pointed out, myths occurring in many other tribes in certain cases have been utilized for ritualistic myths. Thus it is patent that they are secondarily adapted for such uses. Among the Menomini (Skinner) such is not the case; the myths do not occur elsewhere out of their ritualistic setting. But the ritualistic myths of both these tribes are not comparable with those of the Foxes in the details given. Yet there is one point in which the Fox ritualistic origin myths resemble those of the Menomini; that is, that the elements do not occur elsewhere outside their setting.

Some of the songs of the Fox ritualistic origin myths occur among the Kickapoo, which shows that they must be rather ancient. Unfortunately the Kickapoo as well as the Sauk ritualistic origin myth is at present unknown. In so far as Kickapoo folk-lore and mythology are extremely close to Fox (as I have recently shown), and as Fox, Sauk, and Kickapoo are extremely closely related linguistically, it is the more to be regretted, for it might prove that not only the same type of ritualistic origin myths occurs in all three, but also the same myths, which in this case would go back to a hoary antiquity unless they have spread by dissemination. In this connection it must be stated that our knowledge of Sauk folk-lore and mythology is too scanty to permit us to determine how close it is to Fox.

In so far as Fox origin myths are all of one type, it is clear that literary systematization has taken place. In other words we cannot regard the Fox ritualistic origin myths as the actual history of how certain ceremonies were introduced among the Fox Indians. This is somewhat confirmed by the fact that the Ojibwa have some of the ceremonies that the Fox ritualistic origin myths account for, but apparently lack the origin myths. It is, however, possible that they have simply not been thus far recorded. Yet today there is a large amount of Ojibwa mythology published, and Dr. Jones' unpublished material (which I am editing

for publication) is very bulky; nevertheless in both the systematic origin myth of the Fox type is absent. Only a single Ojibwa myth in Dr. Jones' collection shows a resemblance to the Fox type of ritualistic origin myth. Both the Potawatomi and Cree to my own knowledge also possess certain ceremonies which Fox ritualistic origin myths account for, but unfortunately our knowledge of their folk-lore and mythology is too limited to compare these with those of the Foxes. Summing up, we must say that at present we cannot prove that the Fox ritualistic origin myths were invented to account for the existing ceremonies, though this may have been the case. On the other hand it is entirely possible that certain individuals did have religious experiences and did initiate ceremonies which subsequently were utilized in ritualistic origin myths. Unfortunately there is too little comparative material from closely cognate Algonkin tribes at present available to settle these problems.

As to the language employed in the Fox ritualistic origin myths: The words are unusual and archaic. The set speeches are interspersed with variations of a mystic word *no tti* (so written in the current syllabary), the exact translation of which is difficult. Words are considerably mutiliated in the songs and would rarely be intelligible in themselves. They must be explained in full by informants, to make their meaning at all clear. Padding by mere vocables also occurs in considerable profusion. Though these are blemishes from our point of view, from the native standpoint they are not. A single word or phrase will recall to the Fox Indian the entire thought, which is all that is desirable from their point of view.

In closing, I may say that the genuineness of these ritualistic origin myths is attested by the facts (1) that some of the songs contained in them occur among the Kickapoo; (2) that I have heard some of the songs in the appropriate existing Fox ceremony; (3) that in other cases the informant has been gauged by his other stories—if this latter material checks up well, there being reason to doubt his honesty in regard to the ritualistic origin myths; and (4) that Indians are quite incapable of inventing long, sustained, origin myths without internal evidence of fraud.

ARCHEOLOGY.—*The relation of Sun Temple, a new type of ruin lately excavated in the Mesa Verde National Park, to prehistoric "towers."*[1] J. WALTER FEWKES, Bureau of American Ethnology.

During the summer of 1915, under the direction of the Secretary of the Interior I carried on excavation and repair of ruins in the Mesa Verde National Park. This work was a continuation of that already accomplished on these cliff-dwellings: Cliff Palace, Spruce-tree House, and Balcony House. The general plan was to bring to light any types of ruins existing in the Park different from those already known, in order to enlarge our knowledge of the character or culture of prehistoric man on this reservation.

Cliff Palace, which lies in one of the canyons of the Mesa Verde, was excavated and repaired in 1909, and at that time a pile of stones was discovered on the point of Chapin Mesa, across Cliff Canyon. The artificial character of marking found on stones on the surface of this mound and the great quantity of debris suggested the former existence of a building of large size. A small fragment of wall projected above the surface of the mound on which grew many old trees and bushes, giving evidence that the place had long been deserted by human beings.

The government work on this mound extended from August 10 to the close of October, 1915, and a report on the more popular phases of this work has already been transmitted to the Secretary of the Interior,[2] to be followed by a more extended account for the Secretary of the Smithsonian Institution. The following account gives a summary of the work thus far accomplished and a brief description of the ruin.

There was brought to light a type of ruin hitherto unknown in the park, and the building excavated shows the best masonry and is the most mysterious structure yet discovered in a region rich in so many prehistoric remains. Although at first there was some doubt as to the use of this building, it was early recognized that it was not con-

[1] Published by permission of the Secretary of the Smithsonian Institution.

[2] See, Excavation and Repair of Sun Temple, Mesa Verde National Park. Dept. of Interior, 1916. Also, newspaper bulletin released January 16, 1916.

structed for habitation, and it is now believed that it was intended for the performance of rites and ceremonies; the first of its type yet recognized in the Southwest.

The ruin was purposely constructed in a commanding situation in the neighborhood of large inhabited cliff houses. It sets somewhat back from the edge of the canyon, but near enough to present a marked object from all sides, especially the neighboring mesas. It must have presented an imposing appearance, rising on top of a point above inaccessible, vertical cliffs. No better place could have been chosen for a religious building in which the inhabitants of many cliff dwellings could gather and together perform their great ceremonial dramas (see fig. 1).

The ruin was found to have the form of the large letter D, as shown in the accompanying illustration (fig. 2). It was composed of two sections, one of which may be called the original building, and the other the Annex. The side wall, which was situated on the south side, is 121.7 feet long. The whole building is 64 feet wide. The walls, including the central core of rock and adobe, average four feet in thickness. The entire outer facing of the wall is composed of well cut stones, some of which were smoothed by rubbing. There are about 1000 feet or more, containing 28,000 cubic feet of masonry. It is estimated that the building was once several feet higher than it is at the present time.

The rooms in this building vary in form and type, one kind being circular, the other rectangular. The circular rooms are identified as kivas, or sacred rooms; the purpose of the rectangular rooms is unknown. There are two circular rooms, or kivas, of about equal size in the original building, and a third occupies the center of the Annex.

There are 23 other rooms; 14 of these are in the original building, and have parallel walls; several have curved walls, others straight. Of the rooms with curved walls three had entrances from the roofs, four had lateral doors into the plaza, and the remainder are arranged in two series, the members of which communicate with each other.

Not a single room, either circular or rectangular, shows any signs of plastering, but all joints between stones from the bottom to the top were carefully pointed with adobe and generally chinked with stones, the impressions of human fingers and palms of small hands of the workmen, probably women, still showing in the clay mortar.

The principle of the arch was unknown, but the corners were practically vertical, implying the use of a plumb bob. The curved walls are among the best in the ruin. Outside the main building is a circular building with walls four feet thick, which closely resembles the base of a tower. This was probably intended for ceremonial rites. One of the most interesting features is the embellishment of the walls by geometrical figures cut in their surfaces—a rare form of decoration. Several stones bearing incised figures were set in the walls. Generally the designs are geometric, but there are others, including the figure

Fig. 1. View of Sun Temple from the southeast.

of a ladder leaning against a wall, turkey tracks, and the conventional sign for flowing water.

The importance of these incised figures on stones set in walls lies in the fact that they seem to indicate an advance in architectural decoration not represented in other prehistoric buildings in the Southwest. They may be regarded as first steps in mural sculpture, a form of decoration that reached such an advanced stage in old ruins in Mexico and Central America. Each figure may have had a special meaning or symbolic significance connected with the room in which it was placed, but these figures seem to me to have been introduced rather for ornament or decorative effect.

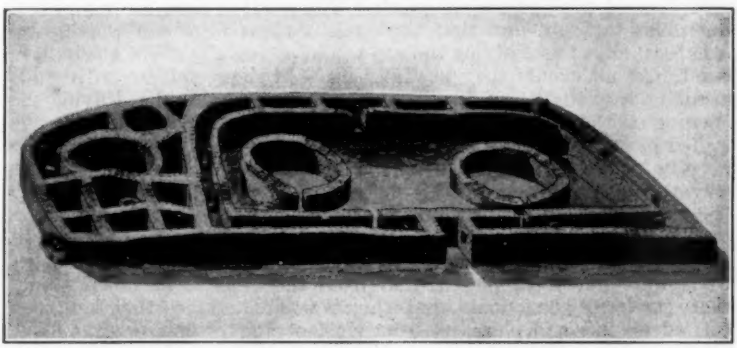

Fig. 2. Perspective view of Sun Temple from the southwest.

The argument that appeals most strongly to my mind as supporting the theory that Sun Temple was a ceremonial building is the unity shown in its construction. A preconceived plan existed in the minds of the builders before they began work on the main building. Sun Temple was not constructed haphazard, nor was its form due to addition of one clan after another, each adding rooms to an existing nucleus. There is no indication of patching one building to another, so evident at Cliff Palace and other large cliff dwellings. The construction of the recess of the south wall, situated exactly, to an inch, midway in its length, shows it was planned from the beginning.

We can hardly believe that one clan could have been numerous enough to construct a house so large and massive: its walls are too extensive; the work of dressing the stones too great. Those who made it must have belonged to several clans fused together; and if they united for this common work, they were in a higher state of sociological development than the loosely connected population of a cliff dwelling.

In primitive society only one purpose could have united the several clans who built such a structure, and this purpose must have been a religious one. This building was constructed for worship, and its size is such that we may practically call it a temple.

The fine masonry, the decorated stones found in it, and the unity of the plan stamp Sun Temple as the highest example of Mesa Verde architecture. The walls were constructed of the sandstone of the neighborhood. Many stone hammers and pecking stones were found in the neighborhood.

One of the most remarkable features of the structure is a fossil set in the outer wall near the southwest corner. Mr. F. H. Knowlton of the U. S. Geological Survey has identified this as the fossil leaf of a palm tree of the Cretaceous epoch. The point is that the rayed leaf resembles the sun, and that the ancient races were sun worshipers. A natural object resembling the sun would powerfully affect a primitive mind. At all events they partially inclosed their emblem with walls in such a way that the figure is surrounded on three sides, leaving the opening on the fourth, or west side. There can be no doubt that the walled inclosure was a shrine, and the figure in it may be a key to the purpose of the building. The shape of the fossil on the rock suggests a symbol of the sun, and if this suggestion be correct, there can hardly be a doubt that solar rites were performed about it.

It is impossible to tell when Sun Temple was begun, how long it was building, or when it was deserted. There are indications that its walls were never completed; and from the amount of fallen stones there can hardly be a doubt that when it was abandoned they had been carried up in some places at least six feet above their present level. The top of the wall has been worn down at any rate six feet in the interval between the time it was abandoned and the date of my excavation of the mound. No one can tell the length of this interval in years.

We have, however, some knowledge of the lapse of time, because the mound had accumulated enough soil on its surface to support the growth of large trees. In the Annex, near the summit of the highest wall, there grew a juniper or red cedar of great antiquity, alive and vigorous when I began work. This tree undoubtedly sprouted after the desertion of the building and grew after a mound had developed from fallen walls. Its roots penetrated into the adjacent rooms and derived nourishment from the soil filling them. It is not improbable that this tree began to grow on the top of the Sun Temple mound shortly after the year 1540, when Coronado first entered New Mexico, but how great an interval elapsed during which the walls fell to form the mound in which it grew and how much earlier the foundations of the ruined walls were laid no one can tell. A conservative guess of 250 years is allowable for the interval between construction and the time the cedar began to sprout, thus carrying the antiquity of Sun Temple back to about 1300 A.D.

From absence of data the relative age of Sun Temple and Cliff Palace is equally obscure, but it is my firm conviction that Sun Temple

is the younger, mainly because it shows unmistakable evidences of a higher sociological condition of the builders; but here again we enter a realm of speculation which merely adds to the mystery of the building.

Comment has been made on the fact that practically no household implements were found in the rooms, which has been interpreted to mean that the building was never finished. It also signifies that the workmen did not live in or near it during construction. On the theory that this building was erected by people from several neighboring cliff dwellings for ceremonies held in common, we may suppose that the builders came daily from their dwellings in Cliff Palace and other houses and returned at night, after they had finished work, to their homes. The trails down the sides of the cliffs, which the workmen used, are still to be seen. The place was frequented by many people, but there is no evidence that any one clan dwelt near this mysterious building during its construction.

Perhaps the most important result of my explorations at the Mesa Verde National Park last summer was the unearthing for the first time of this large, mysterious building bearing evidence that it was constructed solely for religious purposes. This interpretation is very important, if correct; and in order to test the theory by reference to other ruins I have studied in a comparative way related structures that have certain architectural features in common with Sun Temple. Among the most striking of these are the problematical buildings known as "towers," represented by a number of examples in southwestern Colorado and southeastern Utah.

The existence along the Lower Mancos, on the San Juan, and in the canyons of the McElmo, of a type of ruins hitherto unrecorded in the Southwest, designated as "towers," was made known in 1876 and 1879 by Mr. W. H. Jackson[3] and Mr. W. H. Holmes.[4] Since that date, now almost 40 years ago, the figures they published have been frequently reprinted,[5] but the buildings themselves still await systematic excavation and study. Work

[3] Ancient Ruins in Southwestern Colorado. Rept. U. S. Geol. & Geog. Surv. 1876.

[4] Report on the Ancient Ruins of Southwestern Colorado examined during the Summers of 1875 and 1876. 10th Ann. Rept. U. S. Geol. & Geog. Surv. 1879.

[5] In *Search for a lost race*, Illustrated American, May, 1892. In this article Mr. Gunckel adds a few new observations of interest, mainly regarding distribution of towers; no excavations were made. See also, PEET, STEPHEN DENISON: *The Cliff Dwellers and Pueblos*. American Antiquarian, Chicago, 1899.

at Sun Temple has stimulated my desire to know more of architectural details and especially the use to which these towers were formerly put. So far as the question of use is concerned their resemblances to ceremonial rooms called kivas would appear conclusive. Let us consider some of the known architectural features of these towers, on the theory that they are ceremonial in character.

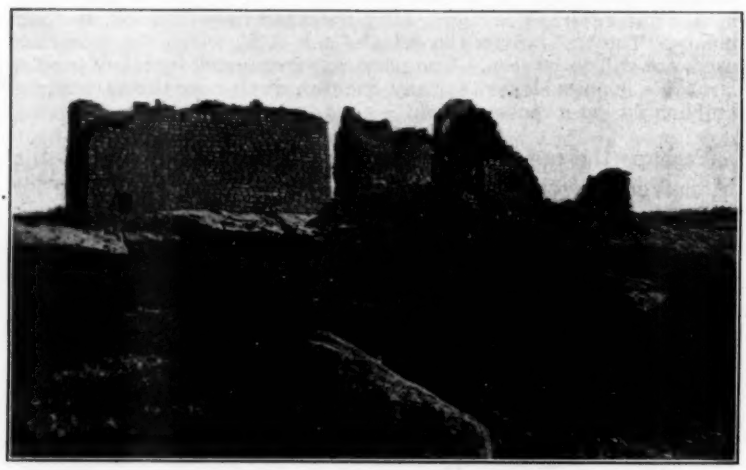

Fig. 3. Tower ruin in Ruin Canyon, Utah.

The central room of one of these towers is circular in form, suggesting a kiva, but its inner walls show no evidences of the former presence of pedestals, or pilasters, or supports of a roof. Evidently if a roof once covered the central room, it was not vaulted as in the majority of circular kivas, but flat, the beams supporting it having been laid parallel, with ends resting on top of the walls. One of the characteristic features of a typical tower is the double wall with intervening rooms separated by partitions.[6] Unfortunately we do not know the character of the floors of these towers, as they still await the spade of the arche-

[6] I am inclined to doubt the existence of triple walled towers.

ologist; but so far as I am aware, evidence is strong that they belong to the second type of circular kivas, those with flat roofs and destitute of columns for support of the roof beams.

One of the so-called towers described by Professor Holmes is said by him to be 140 (138) feet in diameter, this dimension suggesting a large ceremonial building like Sun Temple rather than a tower or kiva. I suspect that, if the architecture of the building containing the tower referred to by Professor Holmes were better known, it would be found to have a straight wall on the side above the cliff and a D-shaped, rather than a circular, wall about it.

Another "tower" described by the same author as set in the midst of secular rooms is evidently a kiva with two encircling walls, surrounded by rooms separated by partitions. The strong resemblence of the Annex, or western end of Sun Temple, to such a tower leaves little doubt that both were identical in use, being sacred enclosures. In a comparison of the Annex with one of the McElmo towers we find in the middle a circular room around which are arranged other rooms, irregularly placed in the former, and modified on one side by confluence with an attachment to the original (main) building. Both have, in the center, ceremonial rooms known as kivas which belong, however, to a type different from the subterranean kivas of Cliff Palace.[7]

As has been elsewhere pointed out, we have in the Mesa Verde culture area circular kivas belonging to two types, one of which, the more common, is subterranean, with vaulted roofs supported on pilasters attached to the inner walls, characteristic ventilators and deflectors, and (generally) a ceremonial opening in the floor styled the *sipapu*. These may be designated vaulted-roofed kivas. The second, or flat-roofed type, to which, *en passant*, it may be said the towers above considered are related, apparently had no pilasters to support the low vaulted roof; consequently the roofs are flat, the ends of the supporting beams extending across the chamber with their extremities resting on the walls of the room, not from one pilaster to another. Some

[7] Semicircular, or D-shaped, Sun temples occur also in Peruvian ruins.

kivas of the flat-roofed type are so surrounded by other rooms that their walls have a sunken appearance, but the chambers are not subterranean. When isolated from the room groups, as are certain modern kivas, they suggest the towers found in the Mesa Verde culture area.[8] The tower kiva is more closely allied to kivas of the second type, represented in Cliff Palace by O and R, and possibly by W (see my account of the excavation and repair of that ruin). I do not regard this type as a transition form connecting circular and rectangular kivas, as suggested by Nordenskiöld, for I find they have distinct origins, but a circular subterranean kiva with pedestals and an arched roof may be related to a round kiva of the second type.[9]

The comparisons that have been made above between the ceremonial rooms in cliff dwellings, towers, and the ruin called Sun Temple have led me to believe that certain of the structures, known as towers, were in reality not lookouts, as commonly believed, but were constructed solely for religious purposes as suggested by the discoverers. On the other hand, some of the towers cannot be regarded as places of worship. Some served probably as lookouts, while many were built for storage, defense, or other purposes. All our theories about their use are tentative, awaiting the time when we shall have more exact knowledge of details, which can be discovered only by scientific excavation of the debris that has fallen around their foundations, obscuring the floors and the connections with other buildings in the immediate neighborhood.

In closing this comparison of Sun Temple or its kivas with San Juan tower kivas, a word may be said in explanation of the term "type ruin." Our Southwest is dotted with prehistoric habitations of several distinct forms, indicating different culture areas, so far as it is possible to determine them in the light of

[8] The circular kivas without pilasters are common lower down the San Juan in the Navaho National Monument. The modern circular kivas belong to the group without vaulted roofs, which includes also towers. A D-shaped kiva of the second type, suggesting D-shaped tower kivas of Ruin Canyon, is found in Oak Tree House.

[9] Antiquities of the Mesa Verde National Park: Cliff Palace. Bull. 51, Bur. Amer. Ethn. 1911.

architecture. Manifestly it is not necessary to excavate carefully and repair all these ruins, even if money were available for that purpose. We need to determine, however, how many kinds of ruins there are, and to get clearly in mind the essential features of each kind, in order to discover culture groups of the prehistoric Southwest. The problem is not unlike that with which the biologist has to deal, and which he has so well worked out in biological textbooks. An intimate knowledge of the anatomy of the starfish, crayfish, frog, cat, and other animals representative of the groups to which they belong, respectively, makes it possible for the zoological student to get a good idea of the anatomy of other members of these groups, the knowledge being gained largely through dissection or through study of "preparations" made by others. These animals serve as types. The same method, with modifications, may be applied in the study of Southwestern archeology, although from the nature of the case preparations of types should be made, for beginners or even for advanced students, by experts.

A few of these type ruins already have been prepared for inspection and for study. The famous Casa Grande in the Gila valley is a good example of a type ruin of the great house ruins of that valley, while Cliff Palace and Spruce-tree House are excellent type ruins of cliff dwellings. Sun Temple seemingly represents a type of ruined buildings of a well defined prehistoric culture area, and as a type will afford the student information bearing on the architecture of other members of a group of ruins one of the main features of which is a specialized building constructed for religious ceremonies.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

PHYSICS.—*The illumination from a radiating disk.* PAUL D. FOOTE. Bureau of Standards Scientific Paper No. 263, pp. 583–586. 1916.

A knowledge of the illumination from a radiating disk is of practical value to engineers, but certain solutions of this problem which have appeared in technical journals have been in error. In this paper is given the correct expression for the illumination produced by a diffusely and uniformly radiating circular disk, at any point on any surface parallel to the disk. P. D. F.

PHYSICS.—*Inclusions in the silver voltameter deposits.* G. W. VINAL and W. M. BOVARD. Bureau of Standards Scientific Paper No. 271, pp. 147–172. 1916.

For the purpose of determining the absolute value of the electrochemical equivalent of silver and the absolute value of the faraday it is necessary to learn the amount of "inclusions" in the silver voltameter deposits. Lord Rayleigh[1] advocated heating the platinum cups with deposits to incipient redness as the simplest method of expelling the inclusions, which are chiefly water and silver nitrate. Richards and Anderegg[2] have recently used this method also, finding the inclusions to be large and variable in amount.

When silver deposits are heated in the platinum cups alloying of the two metals takes place, and on removing the silver the platinum cup shows stains which are brownish or black.

We have found that these stains are platinum black and that they render the weight of the empty platinum crucible very uncertain unless the precaution is taken to heat the cups to incandesence, or to remove

[1] Phil. Trans. A. **175**: 411. 1884.
[2] J. Am. Chem. Soc. **36**: 15. 1915.

the stains by aqua regia before making further deposits. This heating process transforms the platinum black to platinum gray and the loss in weight apparently suffered by the cups may be anything from 0.1 mg. to 5.0 mg., depending on the amount of material adsorbed by the platinum black. The presence of either platinum black or platinum grey in the cup renders the cup unfit for use in measuring the electric current since they exercise a catalytic action on the hydrogen ions present in the solution and therefore the amount of silver deposited is too small to represent all of the electricity which actually passed through the voltameters.

Taking these sources of error into consideration we have made determinations of the losses in weight of deposits from pure electrolyte and find, as the mean of 25 determinations, that it amounts to 0.0040 per cent.

The Bureau of Standards published some time ago an absolute value[3] for the electrochemical equivalent of silver which was obtained by the silver voltameters containing especially pure electrolyte and an absolute current balance of the Rayleigh type. The value found was 1.11805 mg. per coulomb which may be now corrected by subtracting 0.0040 per cent. It thus appears that the value 1.11800 mg. per coulomb which was adopted by the International Electrical Conference in 1908 is in reality within one part in one hundred thousand of the best value which we can now assign to this constant. On this basis, and using the present value for the atomic weight of silver (107.88), we find the farady to be 96,494 coulombs. G. W. V.

PHYSICS.—*A study of instruments for measuring radiant energy in absolute value: an absolute thermopile.* W. W. COBLENTZ and W. B. EMERSON. Bureau of Standards Scientific Paper No. 261. Pp. 49. 1916. *The present status of the determination of the constant of total radiation of a black body.* W. W. COBLENTZ. Bureau of Standards Scientific Paper No. 262. Pp. 30. 1916.

The first paper gives the results of an investigation of an instrument for measuring radiant energy in absolute value. The instrument consisted of a thin blackened strip of metal with a thermopile back of it. The strip of metal functions (1) as a receiver for absorbing radiant energy, (2) as a source of radiation (by heating it electrically) which can be evaluated in absolute measure and (3) as a standard source of radia-

[3] Bulletin Bureau of Standards **10**: 477. 1914.

tion for calibrating the radiometer which includes the galvanometer and the thermopile.

Various widths and thicknesses of metal were used in the receiver which was covered with various kinds of absorbing surfaces of lamp black and platinum black. The instrument was found satisfactory for refined radiometric measurements.

The second paper gives the results of an inquiry into the probable value of the coefficient of total radiation of a uniformly heated enclosure or so-called black body. Experimental data are given on the lack of blackness of the radiator, on the absorption caused by atmospheric water vapor, on the reflecting power of lamp black, etc.

W. W. C.

GEOLOGY.—*Ground water in Lasalle and McMullen counties, Texas.* ALEXANDER DEUSSEN and R. B. DOLE. U. S. Geological Survey Water-Supply Paper No. 375–G, pp. 142–181, with geologic and artesian water maps and sections. 1916.

Lasalle and McMullen counties lie in the Coastal Plain of southwest Texas, where irrigation supplies are valuable. Physiographically they consist of uplands and valleys, the uplands being divided into several parallel belts trending northeast, the valley lands including two groups of Pleistocene terraces. On the uplands are remnants of a late Pliocene plain now nearly destroyed by erosion. The sediments exposed comprise several formations belonging to two systems, the Tertiary and the Quaternary. Deep wells encounter also formations belonging to the underlying Cretaceous system. The beds older than the Quaternary have been elevated and tilted toward the Gulf. The upland gravels and valley deposits were laid down after some tilting and erosion had taken place. An important feature is a difference in the direction in which the formations dip on the opposite sides of a line extending diagonally across the area from the northwest corner of Lasalle County, as suggested by the structure contours. A normal fault having a vertical displacement of probably 40 feet is inferred on the evidence of well sections and the quality of the water. There are several extensive sandy beds separated by beds of impervious clay or shale. The sandy beds are artesian reservoirs and supply flowing wells. Numerous analyses given in the report indicate that almost all the waters exceed 500 parts per million in total mineral content, and nearly two-thirds of them exceed 2000 parts. Sulphate and chloride waters predominate and more than half contain notable amounts of

black alkali. The best water is found in the northwestern part of the area, in the deepest formations. Irrigation on a small scale is practicable west of the fault line. O. E. M.

ENGINEERING.—*Water powers of the Cascade Range, Part III, Yakima River basin.* GLENN L. PARKER and FRANK B. STOREY. U. S. Geological Survey Water-Supply Paper No. 369. Pp. 1–169, with text figures and illustrations. 1916.

This is the third of a series entitled "Water powers of the Cascade Range," prepared by the United States Geological Survey and the Washington State Board of Geological Survey. Part I, containing data on the drainage basins of Klickitat, White Salmon, Little White Salmon, Lewis, and Toutle rivers, in southwestern Washington, was prepared by John C. Stevens and was published in 1910 as Water-Supply Paper 253. Part II, relating to the drainage basins of Cowlitz (except the Toutle), Nisqually, Puyallup, White, Green, and Cedar rivers, on the west side of the Cascade Range, was prepared by Fred F. Henshaw and Glenn L. Parker and was published in 1913 as Water-Supply Paper 313. The Yakima River basin described in this report lies east of the Cascade Range.

The data on which this report and the others are based consist of stream-flow records, river plans and profiles, reservoir surveys, and field reconnaissances of the rivers and the various tributaries. The physical characteristics, economic conditions, and industrial development of the region are described rather fully in order that the limitations to the development of power may be more clearly understood.

G. L. P.

TECHNOLOGY.—*Determination of carbon in steels and irons by direct combustion in oxygen at high temperatures.* J. R. CAIN and H. E. CLEAVES. Bureau of Standards Technologic Paper No. 69. Pp. 10. 1916.

A method has been devised for the determination of carbon in steels and irons by direct combustion in oxygen at 950° to 1100° C., finishing above 1450°, so that the oxides of iron are kept fused for several minutes, in order to give the best possible chance for liberating all the carbon. This method was tested by analyzing various types of plain carbon and alloy steel standards of the Bureau and some of the pig iron standards, and the results obtained for carbon in this way were in the mean about 0.01 per cent carbon above the certificate averages.

J. R. C.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE WASHINGTON ACADEMY OF SCIENCES

The 104th meeting of the Washington Academy of Sciences, the 17th annual meeting, was held in the lecture room of the Cosmos Club, the evening of January 13, 1916, with Vice-President W. S. EICHELBERGER in the chair and about 75 persons present.

The Corresponding Secretary reported a total membership of 486, 179 nonresident, 297 resident, 1 life, 6 honorary, and 4 patrons (1 of whom is also a regular member). This is a net gain of 72 over the membership at the time of the last preceding annual meeting. During the year the Academy lost by death several of its most noted members: CHARLES E. BESSEY, Lincoln, Nebraska; KARL E. GUTHE, Ann Arbor, Michigan; JOSEPH H. HOLMES, Washington, D. C.; MORRIS LONGSTREET, Cambridge, Massachusetts; F. W. PUTNAM, Cambridge, Massachusetts; FRANK A. SHERMAN, Hanover, New Hampshire; GEO. M. STERNBERG, Washington, D. C.; and Mrs. MATILDA COXE STEVENSON, Washington, D. C.

The Recording Secretary reported the previous annual meeting and the 7 subsequent meetings at which scientific papers were presented.

The report of the Treasurer, confirmed by the report of the auditors, showed:

Cash balance, January 1, 1915	$1,597.31
Total receipts during 1915	3,991.31
	$5,588.62
Disbursements, 1915	$3,560.55
Investments, 1915	500.00
Balance, December 31, 1915	1,528.07
	$5,588.62

The Academy's total investments are: $13,090.00.

The following were elected officers for the ensuing year: *President*, L. O. HOWARD; *Corresponding Secretary*, F. E. WRIGHT; *Recording Secretary*, W. J. HUMPHREYS; *Treasurer*, WILLIAM BOWIE; *Vice-Presidents*, representing the: Anthropological Society, J. WALTER FEWKES; Archeological Society, MITCHELL CARROLL; Biological Society, W. P. HAY; Botanical Society, R. H. TRUE; Chemical Society, R. B. SOSMAN; Electrical Engineers Society, C. B. MIRICK; Engineers Society, J. C. HOYT; Entomological Society, W. D. HUNTER; Foresters Society, GEO. B. SUDWORTH; Geographical Society, O. H. TITTMANN;

Geological Society, T. W. VAUGHAN; Historical Society, J. D. MORGAN; Medical Society, E. Y. DAVIDSON; Philosophical Society, L. J. BRIGGS; *Non-Resident Vice-Presidents*, A. G. MAYER and E. C. PICKERING; *Managers, Class of 1919*, G. K. BURGESS and C. L. ALSBERG.

After the election of officers the Academy continued its meeting jointly with the Chemical Society to hear the address of Dr. CARL L. ALSBERG on *The chemical analysis of animal nutrition*,—an instructive survey of the beginning, development, present status, and immediate problems of this exceptionally difficult yet all-important branch of chemistry.

The 105th meeting of the Academy was held in the auditorium of the New National Museum on Thursday evening, March 2, 1916, with President L. O. HOWARD in the chair. Dr. DOUGLAS W. JOHNSON, Professor of Physiography in Columbia University, gave an illustrated lecture on the *Surface features of Europe as a factor in the war*.

The geologic history of Europe was briefly outlined and the resulting present physiographic features explained and illustrated in some detail. It is these features, especially the steep walls on the eastern margin of the "Paris basin," and the lakes, rivers, and swamps of western Russia, that throughout the war have largely determined the routes of advance and retreat, the lines of defense, and the points of attack.

The 106th meeting of the Academy was held in the auditorium of the New National Museum on Tuesday evening, March 23, 1916, with President L. O. HOWARD in the chair and a large audience present. Dr. L. H. BAEKELAND, Member of the Naval Consulting Board, gave an address on *Chemistry in relation to war*. Early experiments were described that led to the chemical discovery and commercial development of dynamite, gun cotton, "T. N. T.," and the various other modern high-power explosives, and the processes of their manufacture outlined. It was explained that in the manufacture of these substances nitric acid is indispensable. The only large-scale sources of this acid, as now manufactured, are "Chili saltpeter" and the nitrogen of the air. Three methods of "fixing" the nitrogen of the air are now in use, two of which were first developed commercially in the United States, though subsequently abandoned owing to the high cost of the necessary power. Both processes are now extensively used abroad, especially in Norway and Germany.

Whether nitrogen shall be "fixed" in America, and aniline dyes and other chemicals manufactured on a large scale, is merely a question of business and dividends, the speaker pointed out, and in no sense a question of scientific ability and chemical knowledge, both of which of high order exist in this country.

W. J. HUMPHREYS, *Recording Secretary*.

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 551st regular meeting of the Biological Society of Washington was held at the Cosmos Club, Saturday, February 26, 1916; called to order at 8 p.m. by President W. P. HAY. Fifty persons were present.

The first paper of the program was by D. E. LANTZ, *An Early Seventeenth Century mammalogist.* This was a review of Edward Topsell's *History of Foure-footed Beastes*, published in London in 1607. Topsell was born about 1538 and at the completion of this, the first general work on mammals published in the English language, was chaplain of the church of St. Botolph, Aldergate, under Richard Neile, Dean of Westminster, to whom the book is dedicated. The work, including illustrations, is largely translated from Conrad Gesner's *Historia Animalium*, published in 1551; but the author quotes also from the works of over 250 other writers—Hebrew, Greek, Latin, German, Italian, and French authorities—including 76 medical treatises. The speaker gave many curious extracts from Topsell, illustrating them with lantern pictures of the animals under discussion, taken from the old wood cuts in the book. The pictures included those of the antelope, an ape monster, the American sloth, the beaver, various kinds of hyenas, the unicorn, the riverhorse, and the Su, an untamable and ferocious animal that has been identified with the American opossum.

The second and last paper of the program was by J. W. GIDLEY, *A talk on the extinct animal life of North America.* Mr. Gidley defined the terms fossil and petrifaction, explained how fossils were formed under various conditions, and how they are discovered by the collector. He discussed the evolution of certain animals as shown by their fossil remains, and as particularly exemplified by horses, elephants, and dinosaurs. He emphasized in especial the unfortunate tendency on the part of paleontologists to try to see in fossil remains ancestral forms of later fossils or of existing animals. The speaker thought that many fossils represented highly specialized types of their kind, some extinct animals being more highly specialized than their present day representatives; in fact in many cases their extreme specialization led to their extinction. In a general way fossil forms represent the evolution of certain groups, but the immediate connecting forms are for the most part lacking.

Mr. Gidley's communication was profusely illustrated with lantern views of fossil-bearing localities, of fossils, and of certain artists' restorations of fossils. It was discussed by Dr. L. O. HOWARD.

M. W. LYON, JR., *Recording Secretary.*